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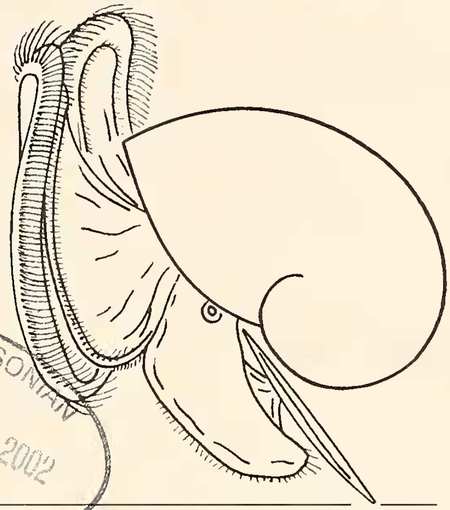
THE

VELIGER



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THE VELIGER

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The Veliger is an international, peer-reviewed scientific quarterly published by the California Malacozoological Society, a non-profit educational organization. *The Veliger* is open to original papers pertaining to any problem connected with mollusks. Manuscripts are considered on the understanding that their contents have not appeared, or will not appear, elsewhere in substantially the same or abbreviated form. Holotypes of new species must be deposited in a recognized public museum, with catalogue numbers provided. Even for non-taxonomic papers, placement of voucher specimens in a museum is strongly encouraged and may be required.

Very short papers, generally not over 750 words, will be published in a "Notes, Information & News" column; in this column will also appear notices of meetings and other items of interest to our members and subscribers.

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New Information on Late Cretaceous, Paleocene, and Eocene Neritid Gastropods from the North American Pacific Slope

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Abstract. Nine species of neritid gastropods from shallow-marine, Upper Cretaceous, Paleocene, and Eocene rocks of the Pacific slope of North America are discussed. Two are new species: *Nerita* (*Bajanerita*?) ***banosensis***, sp. nov., from the Upper Cretaceous (Maastrichtian Stage) "Quinto Silt" member of the Moreno Formation, Merced County, north-central California; and *Nerita* (*Theliostyla*?) ***kennedyi***, sp. nov. from the upper lower to lower middle Eocene ("Domengine Stage") Santiago Formation, near Vista, northern San Diego County, southern California.

An immature specimen of *Corsania* (subgenus?) sp., from unnamed lower Upper Cretaceous (Cenomanian Stage) strata near Dayville, Grant County, east-central Oregon, represents the first confirmed Cenomanian record of a neritid from the Pacific slope of North America.

Corsania (*Januncia*) *rhoga* Saul & Squires, 1997, previously known only from lower Paleocene strata in Lake County, northern California, is reported from lower? and upper Paleocene strata in Los Angeles County, southern California. The late Paleocene *Corsania* (*Januncia*) *janus* Woods & Saul, 1986, previously known only from Baja California Sur, Mexico, is reported from Santa Cruz Island, southern California.

Nerita (*Theliostyla*) *triangulata* Gabb, 1869, a widespread Eocene species is reported for the first time from Washington. Previously unknown, early juvenile morphology and color patterns are described for this species. *Nerita washingtoniana* Weaver & Palmer, 1922, is synonymized with *N.* (*T.*) *triangulata,* and *Nerita cowlitzensis* Dickerson, 1915, is questionably synonymized with the latter. *Neritina martini* Dickerson, 1915, an Eocene species from Washington is tentatively assigned to subgenus *Neritina,* previously known only from the modern record.

INTRODUCTION

Recent field and museum work resulted in the discovery of rare specimens of Late Cretaceous and Early Cenozoic neritid gastropods from the Pacific slope of North America. Two new species, a possible new species, and new information about six other previously known species of neritids were the results of this study. The general areas of the type localities of the new species, as well as the new geographic occurrences of these other species, are shown in Figure 1.

Neritid gastropods are relatively uncommon in the rock record of the northeastern Pacific. This scarcity is due to a variety of reasons. These gastropods commonly lived in rocky shoreline habitats, and these are normally not preserved in the rock record. Also, the record is not continuous because marine neritids, which are warm-water gastropods, only lived in this area during periods of warm climate. In addition, many fossil neritids are overlooked because they resemble naticid gastropods (Saul & Squires, 1997).

The sequence of North American Pacific slope Paleocene and Eocene molluscan stages used in this report was recently put into the current chronostratigraphic framework by Squires (in press). These stages are the following: "unnamed stage" (early Paleocene); "Martinez Stage" (late Paleocene); "Meganos Stage" (latest Paleocene to earliest Eocene); "Capay Stage" (middle early Eocene); "Domengine Stage" (late early to early middle Eocene); "Transition Stage" (early middle Eocene); "Tejon Stage" (middle to late middle Eocene); and Galvinian Stage (late Eocene to earliest Oligocene). These stages, along with the Upper Cretaceous ones, are shown in Figure 2.

Abbreviations used are: CAS, California Academy of Sciences, San Francisco; LACM, Natural History Museum of Los Angeles County, Malacology Section; LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; SDSNH, San Diego Museum of Natural History, San Diego; UCLA, University of California, Los Angeles (collections now stored at

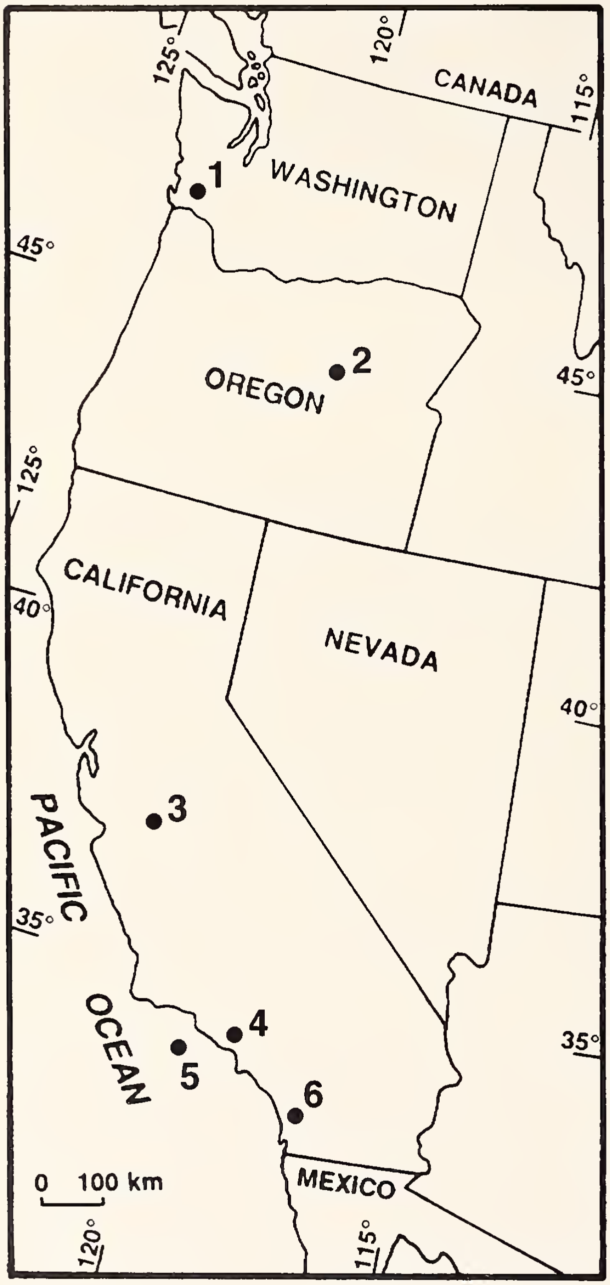


Figure 1. Index map to type localities of the new species and new geographic occurrences of previously named neritids discussed in this study. 1 = "Big Bend" of Cowlitz River near Vader. 2 = Near Dayville. 3 = Los Banos Creek. 4 = Trailer Canyon. 5 = Santa Cruz Island. 6 = Near Vista.

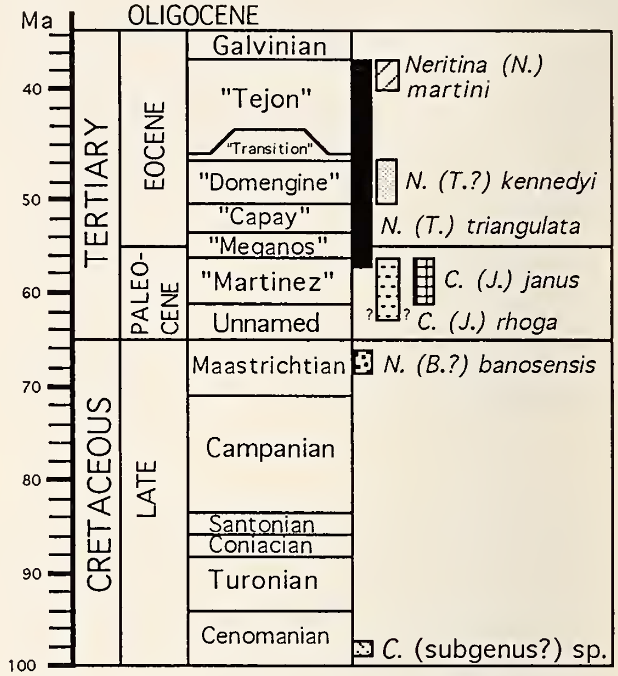


Figure 2. Age and stratigraphic positions of the neritids discussed in this study. Cretaceous stages time scale from Gradstein et al. (1994); Tertiary stages time scale from Squires (in press). *Nerita* (*Theliostyla*) *triangulata* range includes the synonym *Nerita washingtoniana* and the questionable synonym *Nerita cowlitzensis*.

LACMIP); UCMP, University of California Museum of Paleontology (Berkeley); UCR, University of California, Riverside; UWBM, University of Washington (Seattle), Thomas Burke Memorial Washington State Museum [= UW in older literature].

SYSTEMATIC PALEONTOLOGY

Family Neritidae Rafinesque, 1815

Subfamily Neritinae Rafinesque, 1815

Genus *Corsania* Vidal, 1917

Type species: *Corsania douvillei* Vidal, 1917, by original designation; late Early Cretaceous (Aptian Stage), Cors, Lérida, Spain.

Corsania (subgenus?) sp.

(Figures 3–5)

Description: Shell minute (5.4 mm high), broader than high, consisting of about nearly two whorls, spire lowly elevated, body whorl rapidly expanding; suture impressed. Shoulder of body whorl angulate with broad, low-sloping to very slightly concave ramp. Growth lines on ramp prosocline. Body whorl smooth, convex. Aperture moderately large. Deck area narrow. Inner lip slightly irregular with several, very minute prominences (teeth?), especially posteriorly. Outer lip smooth.

Material examined: Hypotype LACMIP 12905 from LACMIP loc. 9936.

Distribution: Unnamed strata about 9.5 km southeast of

Dayville, Grant County, east-central Oregon (LACMIP loc. 9936).

Geologic age: Late Cretaceous (early Cenomanian Stage).

Discussion: The only known specimen of this species is, most likely, an early juvenile, based on its minute size. It is probably a new species, but it is not named at this time because of the incompleteness of knowledge about its morphology as an adult. To name it would only cause problems for future workers in their attempts to make morphologic comparisons.

Squires & Saul (2002) reported an early Cenomanian age and shallow-marine paleoenvironment for the rocks found at LACMIP loc. 9936 near Dayville. They also reported new species of iteriid and actaeonellid gastropods from the same locality.

The Oregon specimen has a high, wide shoulder and rapidly enlarging body whorl which are like those found in *Corsania*. This genus is characterized by ornament consisting of spiral ridges with tubercles crossed by collabral ridges (on portions of the whorls), as well as by teeth on the inner lip (Woods & Saul, 1986). The Oregon specimen does not have any ornament, but this might be the result of having been worn by post-mortem transport, or it could be related to an early juvenile-growth stage of the specimen. The specimen has some very minute irregularities on what appears to be the inner lip. It is possible, however, that the inner lip teeth have been resorbed, which is a common phenomenon in neritids (Woodward, 1892; Cossmann, 1925). Also, it is possible that the deck area, which is a callused area that encompasses the inner lip, has been detached. Broken deck areas are not uncommon in neritids, and Squires & Saul (1993) reported a fossil specimen whose deck area had been pushed into the aperture. The specimen from LACMIP loc. 9936 cannot be assigned to a subgenus because of the possibility that the deck area has been detached. There are two recognized subgenera of *Corsania*; namely, *Corsania* (*Corsania*) Vidal, 1917, and *Corsania* (*Januncia*) Woods & Saul, 1986. *Corsania* (*Januncia*) differs from the former by having a strongly depressed (sunken) deck area. The inner edge of this depressed deck area has a nearly straight trend behind the embellishment of the strong teeth, thereby imparting a double inner lip structure. Better preserved and more mature specimens of the Oregon species are needed in order to determine the subgenus of this species.

This *Corsania* (subgenus?) sp. is the first Cenomanian record of *Corsania* from the Pacific coast of North America. *Corsania* (*Corsania*) *allisoni* Saul & Squires (1997: 139, 141, figs. 22–24) from the Lower Cretaceous (middle Albian) upper member of the Alisitos Formation, Baja California, Mexico, is the earliest *Corsania* on the Pacific coast of North America and the only other record of this genus in this region. *Corsania* (*Corsania*) probably originated in the Old World Tethyan paleobiotic province during the Lower Cretaceous Aptian Stage (Saul & Squires, 1997). *Corsania* (subgenus?) sp. differs from *C.* (*C.*) *allisoni* by not having any ornament, but, as mentioned above, this might be the result of poor preservation and/or growth stage.

The only other neritid on the Pacific coast of North America that might range into the Cenomanian is the Cretaceous *Otostoma*? *atopos* Saul & Squires (1997:138–139, figs. 19–21) known from reworked clasts of late Albian-early Cenomanian age in the Venado Formation of Late Cretaceous (early Turonian) age, northern California. Because of the uncertainty as to exact geologic age of *O.* ? *atopos*, *Corsania* (subgenus?) sp. represents the first confirmed record of a neritid from the Cenomanian Stage of the Pacific slope of North America and extends the northern range of Albian-Cenomanian neritids in this region. *Corsania* (subgenus?) sp. differs from *O.*? *atopos* by having a much lower spire, a low-sloping to slightly concave ramp, and no prominent inner lip teeth.

Subgenus *Januncia* Woods & Saul, 1986

Type species: *Corsania* (*Januncia*) *janus* Woods & Saul, 1986, by original designation; late Paleocene ("Martinez Stage"), Baja California, Mexico.

Corsania (*Januncia*) *rhoga* Saul & Squires, 1997

(Figures 6–8)

Corsania (*Januncia*) *rhoga* Saul & Squires, 1997:142, figs. 25–27.

Holotype: LACMIP 7889.

Type locality: LACMIP loc. 7047, unnamed rocks, Lake County, northern California.

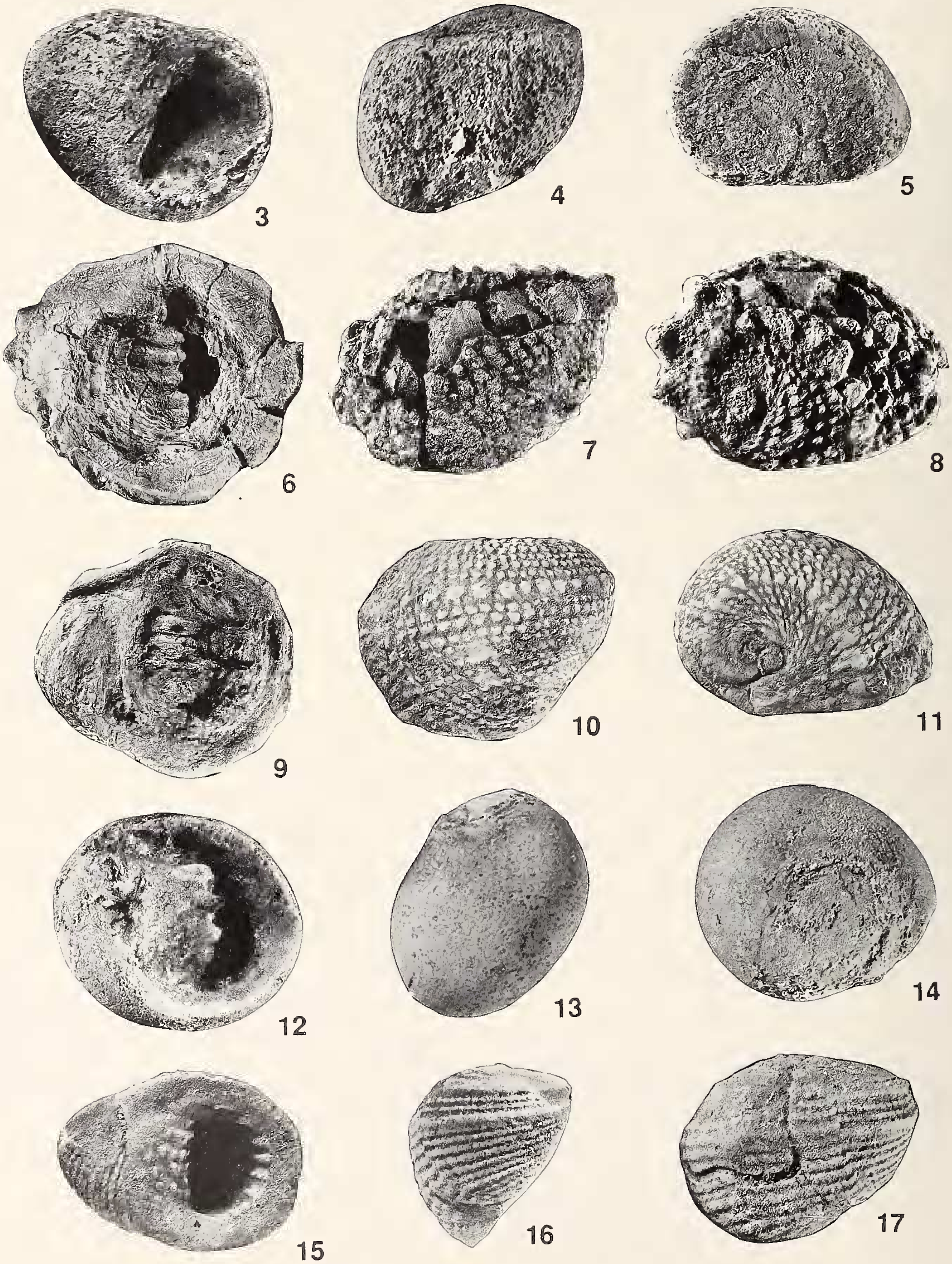
Other material examined: Hypotype LACMIP 12906 from LACMIP loc. 10508, and a specimen from LACMIP loc. 26720.

Distribution: Upper part of Santa Susana Formation, Trailer Canyon, Santa Monica Mountains, southern California (LACMIP locs. 10508 and 26720) and unnamed rocks, Lake County, northern California (LACMIP loc. 7047).

Geologic age: Late early? Paleocene (late "unnamed stage"?) to late Paleocene ("Martinez Stage").

Discussion: Two specimens were found. One is from LACMIP loc. 10508 and is the largest (36.7 mm high and 53 mm wide) and most complete specimen of *C.* (*J.*) *rhoga* (Figures 6–8). This specimen shows, for the first time, the entire inner lip. Five teeth are present, and the two posteriormost ones are the most developed. The other specimen, which is from LACMIP loc. 26720, is complete but does not show the inner lip very well.

The new specimens of *C.* (*J.*) *rhoga* from the Santa



Figures 3–17. All specimens coated with ammonium chloride. Figures 3–5. *Corsania* (subgenus?) sp., hypotype LACMIP 12905, LACMIP loc. 9936, Dayville area, Oregon, height 5.4 mm, ×5.7. Figure 3. Apertural view. Figure 4. Abapertural view. Figure 5. Apical view. Figures 6–8. *Corsania* (*Januncia*) *rhoga* Saul & Squires, 1997, hypotype LACMIP 12906, LACMIP loc. 10508, Santa Monica

Monica Mountains are only the second and third known specimens of this species. They significantly extend the geographical range of *C.* (*J.*) *rhoga* southward by 650 km and extend the geologic range upward into the late Paleocene. At the new locality (LACMIP loc. 10508), *C.* (*J.*) *rhoga* was found in a coralline-algal-rich, micaceous muddy siltstone about 1 m stratigraphically below a 24-m-thick blocky, coralline-algal-limestone interval. The specimens of *C.* (*J.*) *rhoga* were found among numerous specimens of the gastropod *Mesalia clarki* (Dickerson, 1914) and articulated specimens of the bivalves *Plicatula lapidicina* Squires & Saul, 1998, and *Plicatula trailerensis* Squires & Saul, 1998. The rocks that compose LACMIP loc. 10508 were interpreted to be of late Paleocene age and deposited very nearshore, under tropical to subtropical conditions (Squires, 1993a; Squires & Kennedy, 1998; Squires & Saul, 1998).

Januncia originated in the Old World Tethyan paleobiotic province, and the earliest known species is known from the Maastrichtian or Danian of western Iran (Woods & Saul, 1986). *Corsania* (*J.*) *rhoga* is the earliest known species of this subgenus on the Pacific slope of North America.

Corsania (*Januncia*) *janus* Woods & Saul, 1986

(Figures 9–11)

Corsania (*Januncia*) *janus* Woods & Saul, 1986:640–641, figs. 5.1–5.6.

Type specimens: Holotype UCLA 59426; paratypes UCLA 59427–59430.

Type locality: LACMIP loc. 27083, Sepultura Formation, east of Bahía Sebastian Vizcaino, Baja California, Mexico.

Other material examined: Hypotype LACMIP 12907 from LACMIP loc. 23348.

Distribution: Sepultura Formation, east of Bahía Sebastian Vizcaino, Baja California, Mexico (LACMIP loc. 27083) and Pozo Formation, Well Canyon, Santa Cruz Island, southern California (LACMIP loc. 23348).

Geologic age: Late Paleocene ("Martinez Stage").

Discussion: A single specimen is known from the Pozo Formation on Santa Cruz Island. This specimen (Figures 9–11), which is the largest known for this species, is 30.5 mm high and 39 mm wide. The specimen is well preserved exteriorly, but interiorly the deck area is very thin and impossible to clean entirely without destroying it. Careful partial cleaning, however, revealed that the deck area is strongly depressed, which is a diagnostic feature of *Januncia*. The cleaning also revealed three of the six elongate inner lip teeth that characterize *Corsania* (*Januncia*) *janus*.

Woods & Saul (1986) mentioned that *C.* (*J.*) *janus* is similar to *C.* (*J.*) *limata* (White, 1887:196, pl. 15, figs. 6, 7) from Paleocene rocks in Brazil, and the Pozo Formation specimen confirms this comparison.

Doerner (1969) mentioned the same bed (i.e., LACMIP loc. 23348) that yielded the hypotype (LACMIP 12907) of *C.* (*J.*) *janus*. He reported that the molluscan fauna in this bed had lived in shallow, inshore waters of a semi-tropical to tropical environment. Using the presence of *Turritella pachecoensis* Stanton, 1896, he assigned a Paleocene age to the fauna. Saul (1983) considered *T. pachecoensis* to be a subspecies; namely, *Turritella infragranulata pachecoensis* Stanton, 1896. Saul (1983) assigned the rocks from LACMIP loc. 23348 to the "Martinez Stage" of late Paleocene age.

The Pozo Formation specimen of *C.* (*J.*) *janus* provides data on the minimum size of this species' range, which is relatively large. Previously, this species was known only from the Punta Rosarito area, northern Bahía Sebastian Vizcaino, on the western coast of Baja California, Mexico. Today, Santa Cruz Island is about 650 km north of Punta Rosarito. During the Eocene, however, the Pozo Formation was situated 150 km farther south and near what is now known as San Diego. During the Late Cenozoic, Santa Cruz Island underwent about 150 km of clockwise tectonic rotation to its present-day position (Atwater, 1998), and when this rotation is removed, the Pozo Formation occurrence of *C.* (*J.*) *janus* actually represents only a 500-km-range extension to the north.

Genus *Nerita* Linnaeus, 1758

Type species: *Nerita peloronta* Linnaeus, 1758, by subsequent designation (Montfort, 1810); Recent, South Florida, West Indies, and Bermuda.

←

Mountains, California, height 36.7 mm, ×0.9. Figure 6. Apertural view. Figure 7. Abapertural view. Figure 8. Apical view. Figures 9–11. *Corsania* (*Januncia*) *janus* Woods & Saul, 1986, hypotype LACMIP 12907, LACMIP loc. 26720, Santa Cruz Island, California, height 30.5 mm, ×1.1. Figure 9. Apertural view. Figure 10. Abapertural view. Figure 11. Apical view. Figures 12–14. *Nerita* (*Bajanerita*?) ***banosensis*** Squires & Saul, sp. nov., holotype LACMIP 12908, LACMIP loc. 10676, Los Banos Creek, California, height 9 mm, ×4.1. Figure 12. Apertural view. Figure 13. Abapertural view. Figure 14. Apical view. Figures 15–17. *Nerita* (*Theliostyla*) *triangulata* Gabb, 1869, hypotype LACMIP 12909, LACMIP loc. 6298, "Big Bend" of Cowlitz River, Washington, height 7.5 mm, ×4.1. Figure 15. Apertural view. Figure 16. Lateral view. 17. Abapertural view.

Subgenus *Bajanerita* Squires, 1993

Type species: *Nerita* (*Bajanerita*) *californiensis* (White, 1885), by original designation; Late Cretaceous, Baja California, Mexico.

Discussion: *Bajanerita* has an inner lip with a convex trend, and this is one of the main distinguishing features of this subgenus. Re-examination of many specimens of the type species of *Bajanerita* revealed that this genus is also characterized by the presence of a subsutural collar anterior to the suture. Strength of this collar is variable. In addition, the growth lines change from prosocline to nearly straight as they pass from the shoulder onto the collar area. This subsutural collar and its variability in strength are evident in photographs provided by Squires (1993b:figs. 2.3, 2.4, 2.6, 2.8).

Nerita (*Bajanerita*?) ***banosensis*** Squires & Saul, sp. nov.

(Figures 12–14)

Diagnosis: Smooth shell, barely elevated spire, inner lip with four squarish teeth, and a moderately swollen callus.

Description: Shell small (9 mm high), naticiform/neritiform, convex, thin-shelled, consisting of approximately 2½ whorls; spire barely elevated, body whorl rapidly expanding, early whorls nearly hidden by body whorl; suture impressed. Subsutural collar anterior to suture very faint. Body whorl smooth. Growth lines prosocline. Aperture moderately large, subcircular; apertural opening moderately narrow. Deck callus moderately swollen, smooth. Trend of inner lip convex; inner lip with four teeth, squarish, equidistant; posteriormost tooth strongest. Outer lip smooth.

Dimensions of holotype: Height 9 mm, width 8 mm.

Holotype: LACMIP 12908.

Type locality: LACMIP loc. 10676, 36°59′28″N, 120°55′50″W, Moreno Formation, informal "Quinto Silt" member (see Anderson, 1958), Los Banos Creek, Merced County, north-central California.

Other material examined: A specimen from LACMIP loc. 10676, and a specimen from LACMIP loc. 10685.

Distribution: "Quinto Silt" member of Moreno Formation, Los Banos Creek, Merced County, north-central California (LACMIP locs. 10676 and 10685).

Geologic age: Late Cretaceous (middle Maastrichtian Stage).

Discussion: Three specimens were found. Two are from LACMIP loc. 10676, and of these, one is complete and the other is a fragment. The specimen from LACMIP loc. 10685 is also a fragment. Both localities are in close proximity to each other in Los Banos Creek. The spire on the holotype is slightly crushed, and the growth lines on the body whorl are poorly preserved, especially in the vicinity of the suture. None of the specimens shows any teeth on the outer lip, but this might just be a function of growth.

The new species has a convex inner lip, a very faint subsutural collar, and the additional following features of *Bajanerita*: smooth body whorl and several squarish teeth on the inner lip. The new species, however, has four teeth on the inner lip, whereas *Bajanerita* has only three. The new species might belong to *Bajanerita* or to a closely allied subgenus.

Bajanerita is known only from the Pacific slope of North America. Its earliest record is *Nerita* (*Bajanerita*) *californiensis* (White, 1885), from the Upper Cretaceous (upper Campanian to lower Maastrichtian stages) Rosario Formation at Punta Banda, Baja California, Mexico, and Jalama Formation, Santa Barbara County, southern California (Saul & Squires, 1997). Ascending biostratigraphically, two additional possible species of *Bajanerita* are the following: "Capay Stage" *Nerita* (*Bajanerita*?) *larix* Saul & Squires, 1997, from the upper part of the Crescent Formation, southwestern Washington; and Galvinian Stage *Nerita* (*Bajanerita*?) *vokesi* Durham, 1944, from southwestern Washington (Saul & Squires, 1997).

The new species differs from *Nerita* (*Bajanerita*) *californiensis* (White, 1885:pl. 5, figs. 7, 8; Squires, 1993b, figs. 2.1–2.8) by having a much lower spire, a much weaker subsutural collar, four rather than three inner lip teeth, a wider callus, and no outer lip teeth. The new species differs from *Nerita* (*Bajanerita*?) *larix* Saul & Squires (1997:136–137, figs. 9–11) by having a much lower spire, wider inner lip teeth, and no outer lip teeth. The new species differs from *Nerita* (*Bajanerita*?) *vokesi* Durham (1944:156, pl. 17, figs. 11, 12) by having an inner lip with a convex rather than a straight trend and a larger shell size. There might be other differences, but as Saul & Squires (1997) pointed out, the morphology of *N.* (*B.*?) *vokesi* is poorly known.

At both localities in Los Banos Creek where the new species was found, the bivalve *Glycymeris banosensis* Anderson, 1958, is very abundant. Saul (1983) referred to this bivalve as *Glycymeris* (*Glycymerita*?) *banosensis* and interpreted that the specimens are in situ and that they lived in a shallow-water environment. Also present at LACMIP loc. 10685 is the bivalve *Calva* (*Calva*) *varians* (Gabb, 1864) of middle to late Maastrichtian age (Saul & Popenoe, 1992), the gastropod *Gyrodes* (*Sohlella*) *expansus* Gabb, 1864, of middle to late? Maastrichtian age (Popenoe et al., 1987), and the gastropod *Perissitys stantoni* (Stewart, 1927) of late Maastrichtian age (Popenoe & Saul, 1987). Based on association with these last-mentioned three species, the new species is assigned a middle Maastrichtian age, near the middle-late Maastrichtian boundary.

Etymology: The species is named for Los Banos Creek, California where the type locality of the new species is located.

Subgenus *Theliostyla* Mörch, 1852

Type species: *Nerita albicilla* Linnaeus, 1758, by subsequent designation (Kobelt, 1879); Recent, Indo-Pacific.

Nerita (*Theliostyla*) *triangulata*

(Figures 15–27)

Nerita (*Theliostyla*) *triangulata* Gabb, 1869:170, pl. 28, figs. 52, 52a; Vokes, 1939:182, pl. 22, figs. 31, 33, 34; Givens, 1974:61, pl. 5, fig. 4; Givens & Kennedy, 1976: 960, 963, pl. 1, figs. 1–4; Devjatilova & Volobueva, 1981:108, pl. 9, figs. 2–4; Squires, 1987:23, fig. 14; 1992:325–327, figs. 2–18; 1994:48, pl. 2, fig. 6; Oleinik, 1998:383–384, pl. 3, figs. 1, 2.

Nerita triangulata Gabb: Arnold, 1910:14, pl. 14, figs. 12, 12a (figs. repeated in Arnold & Anderson, 1910:pl. 26, figs. 12, 12a); Hanna, 1927:301, pl. 46, figs. 11, 12, 16, 17; Moore, 1968:28, pl. 12a.

? *Nerita cowlitzensis* Dickerson, 1915:58–59, pl. 5, figs. 7a, b; Weaver, 1943:294–295, pl. 63, fig. 11; Nesbitt, 1995: table 1.

Nerita washingtoniana Weaver & Palmer, 1922:28–29, pl. 11, fig. 4); Weaver, 1943:295, pl. 64, fig. 8.

Nerita triangulata Gabb var. *oregonensis* Merriam & Turner, 1937:104, pl. 6, fig. 5; Turner, 1938:95, pl. 19, figs. 10–12; Weaver, 1943:295–296, pl. 64, figs. 10, 13.

Nerita n. sp.: Clark, 1938:701, pl. 4, fig. 6.

Nerita quadrangulata Weaver & Kleinpell, 1963:183, pl. 23, fig. 1.

Description of juveniles: Shell minute (2 to 5 mm high), broader than high, with rapidly expanding body whorl. Spire very low to flattened, apex usually depressed. Posterior part of dorsal surface elevated. Dorsal surface with extremely faint and noded spiral ribs or with distinct, noded spiral ribs. Body whorl with carinate shoulder and, usually, another carina a short distance anteriorly. Very closely spaced, unnoded spiral ribs cover most of body whorl, except near base of whorl. Anteriormost spiral rib carinalike toward outer lip. Aperture large, quadrate (rarely elliptical). Outer lip flared with seven to 10 teeth, not extending to outer lip periphery. Two posteriormost teeth stronger than rest, with tooth next to posteriormost tooth strongest. Three to four small, subequal teeth medially. Deck with five to six granules, arranged loosely in rows. Color bands axial, wavy or non-wavy; some non-wavy bands bifurcate and others do not extend to shell apex. Growth lines prosocline.

Holotypes: Of *N.* (*T.*) *triangulata,* type material missing (*fide* Keen & Bentson, 1944:179). Of *N. cowlitzensis.* CAS 183.02 [= CAS 290]; of *N. washingtoniana* CAS 66548.01 [= UW 197 = CAS 7591].

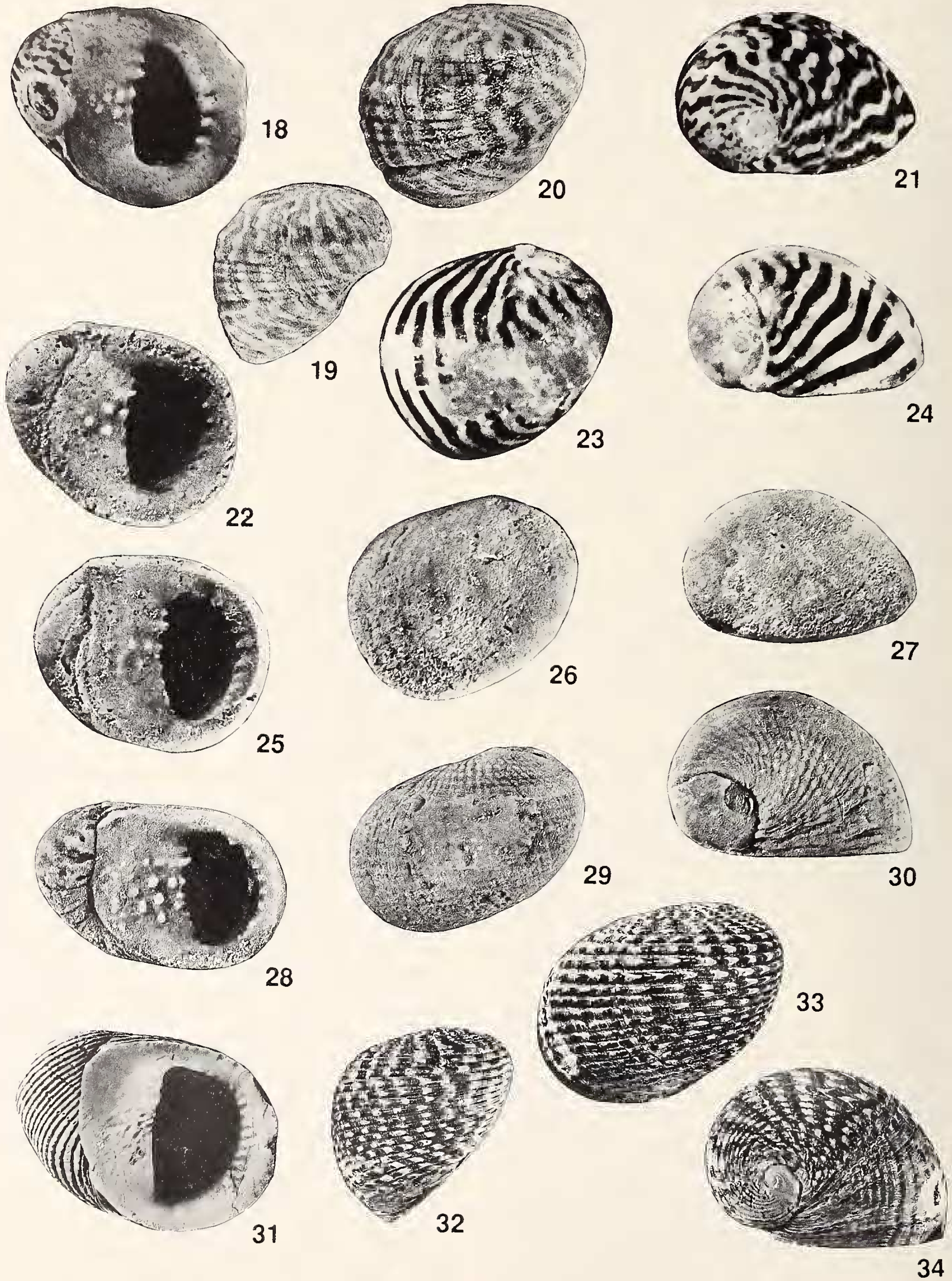
Type localities: Of *N.* (*T.*) *triangulata,* (exact location unknown), Domengine Formation, New Idria area, San Benito County, central California. Of *N. cowlitzensis,* UWBM loc. 232, Cowlitz Formation, Lewis County, southwestern Washington. Of *N. washingtoniana,* UWBM loc. 329, Cowlitz Formation, Lewis County, southwestern Washington.

Other material examined: Hypotypes LACMIP 12909 to 12911 and seven other specimens from "Big Bend" of Cowlitz River, east of Vader, Lewis County, southwestern Washington.

Distribution: San Diego, southern California to southwestern Washington; also present in northwestern Kamchatka.

Geologic age: Late Paleocene ("Martinez Stage") through late middle Eocene ("Tejon Stage"). "MARTINEZ" to "MEGANOS"-"CAPAY" STAGES UNDIFFERENTIATED: Kamchikskaya Formation and Tkapravayamskaya Formation, Cape Getkilnin, northwestern Kamchatka (Oleinik, 1998); "CAPAY STAGE": Capay Formation, Yolo County, northern California and White Tail Ridge formation (informal) [formerly referred to as the upper Umpqua formation (informal) and the Lookinglass Formation (see Squires, 1998)], southwestern Oregon (Merriam & Turner, 1937; Turner, 1938); "DOMENGINE STAGE": Delmar Formation, San Diego, southern California (Hanna, 1927; Givens & Kennedy, 1979; "Santiago Formation" (formerly referred to as the Delmar Formation, in the Vista area, northern San Diego County (Givens & Kennedy, 1976; Squires, 1992); Matilija Sandstone, Pine Mountain area, Ventura County, southern California (Givens, 1974); Matilija Sandstone?, Whitaker Peak area, Ventura County, southern California (Squires, 1987); Domengine Formation, Coalinga area, central California (Vokes, 1939). "TEJON STAGE": Sacate Formation-"Coldwater" Sandstone [formerly referred to as the undifferentiated Sacate-Gaviota Formation, Santa Barbara County, southern California (see Squires, in press)] (Weaver & Kleinpell, 1963); Markley Formation, Solano County, northern California (Clark, 1938); Cowlitz Formation, Lewis County, southwestern Washington (new information).

Discussion: Even though the shallow-marine to brackish-marine *Nerita* (*Theliostyla*) *triangulata* is the most geographically widespread (and the most geologically long-ranging) neritid gastropod in the Paleogene rock record of the northern Pacific, it is reported here for the first time from Washington. The Washington specimens (a total of 10) are all from the upper middle Eocene Cowlitz Formation ("Tejon Stage") in the vicinity of the "Big Bend" of the Cowlitz River, east of Vader, Lewis County. The Cowlitz Formation was deposited at an estimated paleolatitude of 40°N to 45°N, in warm-tropical to subtropical, shallow-marine and marginal-marine environments associated with a prograding river-dominated delta (Nesbitt, 1995). This formation is chronostratigraphically near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the top of the "Tejon Stage" and ranges in age from approximately 39 to 36 Ma (Nesbitt, 1995; Squires, in press). The occurrence of *N.* (*T.*) *triangulata* in "Tejon Stage" rocks in Washington reinforces how far north warm-water mollusks ranged during the middle to late Eocene on the Pacific slope of North America.

Nerita (*T.*) *triangulata* is a rare taxon in the Cowlitz Formation (E. Nesbitt, personal communication). The largest known specimen (7.5 mm high) of this species from this formation is illustrated in Figures 15–17. This specimen shows all the diagnostic morphologic features described by Squires (1992) for *Nerita* (*Theliostyla*) *triangulata.* All the other known specimens of *N.* (*T.*) *triangulata* from the Cowlitz Formation are juveniles, and most of these are between 2 and 3 mm high. A few show color patterns. Many of the juvenile specimens from this formation were collected in bulk samples taken from LACMIP loc. 6297 by R. L. Squires. The morphology of the juvenile stage of *N.* (*T.*) *triangulata* was previously not known.

The holotype of *Nerita washingtoniana* Weaver & Palmer, 1922, is a worn juvenile 2 mm high (Figures 25–27). Unfortunately, the shell on the body whorl is missing. The overall shape of the shell and the morphological details of the aperture are identical to that of *Nerita* (*Theliostyla*) *triangulata,* although the granules on the deck area are less prominent because of abrasion. *Nerita washingtoniana,* therefore, is synonymized with *N.* (*T.*) *triangulata.* Weaver & Palmer (1922:295) mentioned that the color bands on their species "extend regularly over the surface of the body whorl without a zigzag or wavy pattern." They did not illustrate a specimen showing this original coloration, nor did they give a catalog number to any specimen that shows it. The specimen illustrated in Figures 22–24 fits their description, and this specimen was collected by R. L. Squires.

The holotype of *Nerita cowlitzensis* Dickerson, 1915, is a juvenile 5 mm high (Figures 28–30). It is a somewhat worn specimen, and the early part of the body whorl is missing its shell. Although the carina on the body whorl shoulder is evident, other carinae are poorly evident, and this is probably because of abrasion. A second carina, a short distance anterior to the body whorl shoulder, is very faint.

Dickerson (1915) reported that the shoulder of *Nerita cowlitzensis* is less angulated than *N.* (*T.*) *triangulata.* Squires (1992) reported that *N. cowlitzensis* differs from *N.* (*T.*) *triangulata* by being smaller, nodose only on the dorsal surface, body whorl with only minute sculpture, and aperture more elongate. The apparent differences of angulation and sculpture could be explained by taking into account that the holotype of *N. cowlitzensis* is a worn specimen of an early juvenile. The aperture of the holotype of *N. cowlitzensis* is more elongate than is common in specimens of *N.* (*T.*) *triangulata.* This greater elongation might be the result of slight distortion during post-burial compaction, or it might be the result of a paleoenvironmental factor. Better preserved specimens of *N. cowlitzensis,* however, are needed to positively confirm whether or not these species are the same. We questionably synonymize them because, other than the apparent differences mentioned above, their deck areas, inner lips, and outer lips are identical.

Nerita (*Theliostyla*?) ***kennedyi*** Squires & Saul, sp.nov.

(Figures 31–34)

Diagnosis: A globose *Theliostyla* with a flattened spire, rounded body whorl, convex ramp, numerous subequal spiral ribs, low wrinkles and elongate nodes on deck callus, and a color pattern consisting of alternating collabral bands of light and dark.

Description: Shell medium small, broader than high, globose, 2¾ whorls, with rapidly expanding body whorl. Uppermost spire flattened, apex immersed. Suture impressed. Ramp convex. Body whorl shoulder rounded. Earliest 1½ whorls smooth, rest of teleoconch covered with numerous narrow, closely spaced spiral ribs with interspaces narrower than ribs; three to four spiral ribs on rounded body whorl shoulder slightly stronger and more widely spaced than elsewhere; spiral ribs on medial part of body whorl can be somewhat narrower with narrower

←

Figures 18–34. Specimens coated with ammonium chloride, unless otherwise noted. Figures 18–27. *Nerita* (*Theliostyla*) *triangulata* Gabb, 1869, Vader area, Washington. Figures 18–21. Hypotype LACMIP 12910, LACMIP loc. 22536, height 3 mm. Figure 18. Apertural view (uncoated), ×11. Figure 19. Lateral view, ×10. Figure 20. Abapertural view, ×11. Figure 21. Apical view (uncoated), ×10. Figures 22–24. Hypotype LACMIP 12911, LACMIP loc. 6297, height 2 mm, ×16.5. Figure 22. Apertural view. Figure 23. Abapertural view (uncoated). Figure 24. Apical view (uncoated). Figures 25–27. Holotype CAS 66548.01 of *Nerita washingtoniana* Weaver & Palmer, 1922, height 2 mm, ×16.5. Figure 25. Apertual view. Figure 26. Abapertual view. Figure 27. Apical view. Figures 28–30. ? *Nerita* (*Theliostyla*) *triangulata* Gabb, 1869, holotype CAS 183.02 of *Nerita cowlitzensis* Dickerson, 1915, height 5 mm, ×5.4. Figure 28. Apertural view. Figure 29. Abapertural view. Figure 30. Apical view. Figures 31–34. *Nerita* (*Theliostyla*?) ***kennedyi*** Squires & Saul, sp.nov., holotype SDSNH 67066, SDSNH loc. 4105, Vista area, California, height 14.7 mm, ×2.2. Figure 31. Apertural view. Figure 32. Lateral view (uncoated). Figure 33. Abapertural view (uncoated). Figure 34. Apical view (uncoated).

interspaces than elsewhere. Spiral ribs minutely beaded on ramp and near base of body whorl. Aperture large, quadrate. Outer lip flared, smooth. Outer lip interior with approximately 17 evenly spaced teeth not extending to outer lip periphery, but extending a short distance interiorly; eight medial teeth strongest, others become increasingly weaker posteriorly or anteriorly; teeth tend to align with spiral ribs on exterior of shell. Inner lip with eight teeth; two posteriormost ones strongest (tooth 1 removed from being the posteriormost the strongest), next three teeth slightly weaker, and anteriormost three the weakest. Deck area sharply demarcated from shell; broad and callused, with about 12 very loosely arranged, transverse rows of low ridges or wrinkles (on posterior part of deck and coincident with spiral ribs) and elongate nodes (on anterior part of deck) somewhat coincident with inner lip teeth. Original color pattern with alternating collabral bands of light and dark, with zigzag borders. Growth lines prosocline.

Dimensions of holotype: Height 14.7 mm, width 18 mm.

Holotype: SDSNH 67066.

Type locality: SDSNH 4105, 33°09′45″N, 117°12′37″W, Santiago Formation, near Vista, northern San Diego County, southern California.

Other material examined: Two specimens from SDSNH loc. 3522.

Distribution: Santiago Formation near Vista, northern San Diego County, southern California (SDSNH locs. 3522 and 4105).

Geologic age: Late early to early middle Eocene ("Domengine Stage").

Discussion: Three specimens were found. A complete and exceptionally well preserved one (holotype) is from SDSNH loc. 4105, which is from the same general location of UCR loc. 4865 reported by Givens & Kennedy (1976). They reported that the mollusks at UCR loc. 4865 are indicative of the "Domengine Stage" and that they lived in a low-energy, very shallow (0–30 m) brackish-water or marine environment, perhaps a lagoon or estuary.

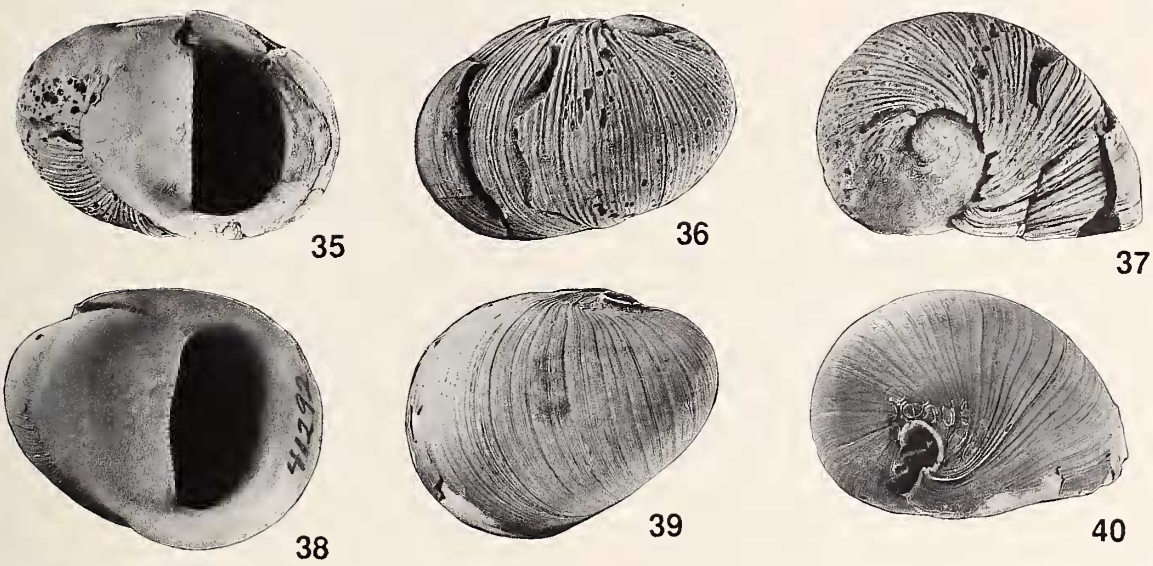
The other two specimens of the new species are partial specimens from SDSNH loc. 3522. The mollusks at this latter locality are also indicative of the "Domengine Stage" and lived in a brackish-marine lagoon and were transported a short distance seaward and concentrated within a channel complex, along with land-plant remains (Squires, 1992).

Theliostyla probably originated in the Old World Tethyan paleobiotic province and immigrated to the Pacific slope of North America during the late Paleocene. The earliest record of this subgenus in the rock record of the northeastern Pacific is *Nerita* (*Theliostyla*) n. sp.? Woods & Saul, 1986, of probable late Paleocene age in Baja California. Ascending biostratigraphically, the other known species of *Theliostyla,* besides the new species, from the Pacific slope of North America are the following: "Capay Stage" *Nerita* (*Theliostyla*) *olympia* Squires & Goedert, 1994, from southwestern Washington; "Capay Stage" through "Tejon Stage" *Nerita* (*Theliostyla*) *triangulata* Gabb, 1869 (see previous discussion) from widespread localities; "Tejon Stage" *Nerita* (*Theliostyla*) *crooki* Clark, 1938, from northern California; middle Miocene *Nerita* (*Theliostyla*) sp. from southern California (Susuki, 1978); middle Miocene *Nerita* (*Theliostyla*?) *joaquinensis* Addicott, 1970, from central California; and Pleistocene to Recent *Nerita* (*Theliostyla*) *funiculata* Menke, 1851 [invalid synonym: *Nerita* (*Theliostyla*) *bernhardi* Récluz, 1850] from Pleistocene rocks in Baja California (Durham, 1950) and living in warm waters of Baja California through the Gulf of California and southward to Peru and the Galápagos Islands (Keen, 1971).

Theliostyla is normally characterized by granules (pustules) on the deck area. On some species, both fossil and modern, however, there can be considerable variability in the shape of the granules. Specimens of *Nerita* (*T.*) *triangulata* provide an Eocene example. Examination of 43 well preserved late juvenile to adult individuals from SDSNH loc. 4105 revealed a gradation (independent of size) from specimens having only well developed granules on the callus (many specimens) to those having only wrinkles on the callus (few specimens). In some cases, the wrinkles are coincident with spiral ribs, just as on the new species. Specimens of *Nerita* (*T.*) *funiculata* provide a modern example. Examination of about 100 juvenile to early adult individual specimens collected by R. L. Squires from Bahía de Los Angeles in the Gulf of California revealed a gradation (independent of size) from specimens having predominantly granules on the callus (most specimens) to those having only wrinkles on the callus (few specimens). Again, the wrinkles are usually coincident with spiral ribs. Some specimens of *N.* (*T.*) *funiculata* even have an almost smooth-deck callus.

The deck area of the new species is known only from the holotype. Although its deck does not have the completely granular ornament that is commonly found in specimens of *Theliostyla,* it could be argued that the new species is within the range of morphology found within the subgenus. However, until specimens, found by future collecting, show the presence of granules on the deck area, it seems prudent to questionably assign the new species to *Theliostyla.*

The new species is very similar to those specimens of *Nerita* (*Theliostyla*) *triangulata* Gabb (1869:170, pl. 28, figs. 52, 52a) that have no carinae on the late part of the body whorl. Squires, (1992:323–329, figs. 1–18) reviewed *N.* (*T.*) *triangulata,* a moderately common gastropod in lower and middle Eocene rocks of the Pacific slope of North America. Based primarily on specimens from



Figures 35–40. All specimens coated with ammonium chloride. Figures 35–37. *Neritina* (*Neritina*?) *martini* Dickerson, 1915, holotype CAS 291, CAS loc. 193, Vader area, Washington, height 18 mm, ×1.7. Figure 35. Apertural view. Figure 36. Abapertural view. Figure 37. Apical view. Figures 38–40. *Neritina* (*Neritina*) *pulligera* Linnaeus, 1766, hypotype LACM 152685, Tjilatjap, Java, height 24 mm, ×1.5. Figure 38. Apertural view. Figure 39. Abapertural view. Figure 40. Apical view.

SDSNH loc. 3522, which is one of the localities where the new species was found, Squires found that most specimens of *N.* (*T.*) *triangulata* have three carinae on the body whorl, some specimens show a gradation from three strong carinae on the early part of the body whorl to faint carinae or no carinae on the late part of the body whorl. The new species differs from *N.* (*T.*) *triangulata* by having no carinae whatsoever on the early part of the body whorl. In addition, the new species differs in the following ways: larger and more globose, slightly stronger spiral ribs, much less beaded spiral ribs, and color pattern arranged in collabral bands. Associated with the new species at SDSNH loc. 4105 are abundant and exceptionally well preserved specimens of *N.* (*T.*) *triangulata.*

The new species is also very similar to *Nerita* (*Theliostyla*) *crooki* Clark (1938:700, pl. 4, figs. 1, 2) from the middle Eocene ("Tejon Stage") Markley Formation, northern California. The new species differs from *N.* (*T.*) *crooki* by having mostly unbeaded spiral ribs and by having weaker teeth on the posterior part of the inner lip.

The nomenclature of the formation that contains the type locality of the new species has been in a state of flux in recent years. Givens & Kennedy (1976) referred to the strata as unnamed. Eisenberg & Abbott (1991) assigned the strata to the Delmar Formation, and Squires (1992) followed this assignment. Walsh (1996) assigned the strata to the Santiago Formation, and this usage is followed in this paper.

Etymology: The species is named for George L. Kennedy, who informed the authors about the specimens of the new species.

Genus *Neritina* Lamarck, 1816

Type species: *Nerita pulligera* Linnaeus, 1766 (ICZN opin. 119, 1931); Recent, southwest Pacific.

Subgenus *Neritina sensu stricto*

Discussion: *Neritina sensu stricto* is low spired and has a smooth or finely dentate inner lip. It has an outer lip that overrides the body whorl and forms a projecting point in the spire area. It also has a very slightly sinuous inner lip (Keen & Cox, 1960) (Figures 37–39). The holotype of *Neritina martini* Dickerson, 1915, discussed below, does not have this projecting point, and its absence is most likely because of poor preservation of this very delicate feature or because of abrasion. The holotype of *N. martini* also has a straight inner lip, and this difference, along with a lack of information about the projecting point, makes the subgeneric assignment of *N. martini* tentative.

Neritina (*Neritina*?) *martini* Dickerson, 1915

(Figures 35–37)

Neritina martini Dickerson, 1915:59, pl. 5, figs. 8a,b; Weaver, 1943:296, pl. 63, fig. 10.

Holotype: CAS 291.

Type locality: CAS loc. 183, Cowlitz Formation, Lewis County, southwestern Washington.

Other material examined: None.

Distribution: Cowlitz Formation, Lewis County, southwestern Washington (CAS loc. 183).

Geologic age: Late middle Eocene ("Tejon Stage").

Discussion: This species is known only from the holotype, which is an adult specimen (height 18 mm, diameter 21 mm) that is well preserved, except for the apical area. Dickerson's (1915:pl. 5, fig. 8a) illustration of the apertural view of the holotype of *N.* (*N.*) *martini* shows the inner lip, whereas Weaver's (1943:pl. 63, fig. 10) illustration of the same view of this specimen shows the aperture plugged with modeling clay.

Neritina is a littoral zone or fresh-to brackish-water gastropod (Fürsich & Kauffman, 1984). Its presence in the Cowlitz Formation is extremely rare, but is compatible with the deltaic setting of the formation. Contemporaneous environments on this delta included brackish-water areas in mudflats and marshes, as well as a freshwater lake within the marshes, all in close proximity to nearshore-marine habitats (Nesbitt, 1995).

Cossmann (1925) reported the geologic range of *Neritina* (*Neritina*) as Middle Jurassic to Recent, whereas Keen & Cox (1960) reported it as Recent only. The latter workers, however, did report the geologic range of *Neritina sensu lato* as Eocene to Recent. Inconsistencies such as these are a reflection of the poor state of knowledge of this group of neritids, which is represented by a paucity of well preserved specimens. Without adequate information about the inner lip and deck area, workers have been understandably uncertain about the identification of the specimens.

Although early workers reported several species of *Neritina* and *Neritina*? from Jurassic and Cretaceous rocks of the western interior of the United States (see Boyle, 1893, for a summation), nearly all of these species subsequently have been re-evaluated and assigned to other genera (e.g., Yen, 1946, 1951; Sohl, 1965; Fürsich & Kauffman, 1984). At least two species have been retained in *Neritina*; namely, *Neritina insolita* Stephenson (1952: 146, pl. 54, figs. 6–8) from the Upper Cretaceous (Cenomanian Stage) Woodbine Formation of Texas and *Neritina* sp. (Dockery, 1993) from Upper Cretaceous (Maastrichtian Stage) strata in Mississippi.

The species of *Neritina* from Paleocene and Eocene rocks of Paris Basin, France have also been reassigned to other genera (Le Renard & Pacaud, 1995:90). Furthermore, it seems to us that the lower Eocene *Neritina unidenta* Aldrich (1911:13, pl. 5, figs. 7, 8), which is the only reported species of *Neritina* from the Paleogene of the Gulf coast of the United States, should be placed in genus *Neritoplica* Oppenheim, 1892, based on the overall shape of the shell and the presence of a single projecting tooth on the inner lip.

An exhaustive study of all fossil occurrences of *Neritina* is beyond the scope of this present investigation, but our rudimentary review of the literature indicates that *Neritina sensu lato* is a rare taxon whose earliest known record is probably the early Late Cretaceous (Cenomanian).

In addition to *Neritina* (*N.*?) *martini,* the only fossil record of *Neritina* on the Pacific slope of North America includes *Neritina* (*Dostia*) *cuneata* (Gabb, 1864) from Upper Cretaceous (Campanian Stage) strata of northern California and *N.* (*D.*) aff. *N.* (*D.*) *cuneata* (Gabb) of Woods & Saul, 1986, which is a very similar, if not conspecific form, from the Upper Cretaceous (Maastrichtian Stage) Tierra Loma Sandstone Member of the Moreno Formation of north-central California (Woods & Saul, 1986). *Dostia* Gray, 1842, is patelliform with seven to nine ridgelike teeth and is morphologically quite distinct from *Neritina sensu stricto.*

The only modern record of *Neritina* on the Pacific slope of North America is *Neritina* (*Clypeolum*) *latissima* Broderip, 1833, known from Acapulco, Mexico to Ecuador (Keen, 1971). *Clypeolum* Récluz, 1842, has a large flaring aperture and is morphologically quite distinct from *Neritina* sensu stricto.

Neritina (*N.*?) *martini* is most like *Neritina* (*Neritina*) *pulligera,* a modern species and the type species of *Neritina* (*Neritina*). Illustrations of this type species are provided in Figures 38–40. *Neritina* (*N.*?) *martini* differs from *N.* (*N.*) *pulligera* by having a more elliptical shape, straight inner lip, and more incised growth lines. As mentioned earlier, whether or not *Neritina* (*N.* ?) *martini* has an outer lip that overrides the body whorl as a projecting point in the spire area cannot be determined.

One other North American fossil species of *Neritina* has been compared to *Neritina* (*N.*) *pulligera.* Stephenson (1952) reported *Neritina insolita* Stephenson from the Woodbine Formation (Cenomanian) of Texas to be very similar to *Neritina pulligera. Neritina* (*N.*?) *martini* and *N. insolita* are also similar and both have a straight inner lip, but the former differs from *N. insolita* by having denticles on the inner lip and having no spiral ribs on the shell.

Acknowledgments. Conrad Carrle (formerly a geology student at California State University, Northridge) found the large specimen of *Corsania* (*Januncia*) *rhoga* and kindly donated it. George L. Kennedy (California State University, San Diego) found the unusual specimens of *Nerita* (*Theliostyla*) from the Vista area, recognized their significance, and informed the authors about them. Lindsey T. Groves (LACMIP) allowed access to collections and obtained difficult-to-find literature.

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